

Foods for infants and children in developing and industrialized countries.

Nutritional, biochemical and educational aspects.

Lillemor Abrahamsson

From the Institute of Nutrition, University of Uppsala, Sweden.

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References



This dissertation is a summary of the following papers, which will be referred to in the text by their Roman numbers:

- I Hambræus, L., Forsum, E., Abrahamsson, L. and Lönnerdal, B.: Automatic total nitrogen analysis in nutritional evaluations using a block digester. *Anal. Biochem.* 72:78–85, 1976.
- II Abrahamsson, L.: A food group system for the formulation of weaning foods in developing countries.
- III Abrahamsson, L., Forsum, E. and Hambræus, L.: Nutritional evaluation of emergency food mixtures based on wheat supplemented by different protein concentrates. *Nutr. Rep. Int.* 9:169–177, 1972.
- IV Velarde, N. and Abrahamsson, L.: Home prepared weaning foods for use in the Altiplano area of South America with special reference to protein quality.
- V Abrahamsson, L. and Hambræus, L.: The protein quality of instant blends for infants and children based on milk or cereals and milk. *Am. J. Clin. Nutr.* 30:441–448, 1977.
- VI Abrahamsson, L., Bengtsson, O., Hambræus, L. and Holm, H.: Protein quality of milk-cereal based foods for infants and children in relation to processing methods and composition of the products.
- VII Abrahamsson, L. and Velarde, N.: Weaning foods in developing and industrialized countries. Comparison of nutritional values.

Introduction

The growth and development of the human being depends on several genetic and environmental factors. The effect of each separate factor is difficult to define (18, 25, 61, 94). The importance of energy and nutrient intake for physical growth and development has been clearly demonstrated in experimental animals. Both transient and long-term effects of malnutrition have been shown in various animal species (108). There

is a rich documentation indicating the importance of adequate diet, both quantitative and qualitative, in combination with freedom from infections, for optimal growth and development in humans (19, 25, 26). The nutritional value of the diet has been shown to have particular impact during periods of fast growth and development.

Recent reports, mainly from developing countries, have clearly documented the fact that the maternal nutrition during pregnancy is of critical importance for the growth and development of the offspring (38, 59). Further, accumulating evidence indicates that the health and nutritional status of the mother will particularly influence not only the amount but also the quality of the breast milk produced (10, 11, 13, 39, 42, 43, 107).

In the Third World countries malnutrition is prevalent, particularly during the weaning period* (15, 23, 63), and is considered the greatest cause of retarded growth and a major contributory factor of the high morbidity and mortality rates observed among older infants and younger preschool children* (23). During the first 4–6 months of life, breast feeding without additional supplements covers the nutritional needs of the infant (67).

After that time the infant must be gradually introduced to family foods, because breast milk alone can no longer meet the increased total energy and nutrient requirements (42, 52, 60, 100, 105). A child of about 10 months

* In this study the weaning period has been defined as the period from 6–36 months of age (106), and the age groups referred to in the following are as suggested by Venkatachalam (106):

young infants	0–6 months
older infants	6–12 months
younger preschool children	12–36 months
older preschool children	36–60 months

needs as much as about one and a half litres of breast milk daily to cover its total energy needs (54, 66).

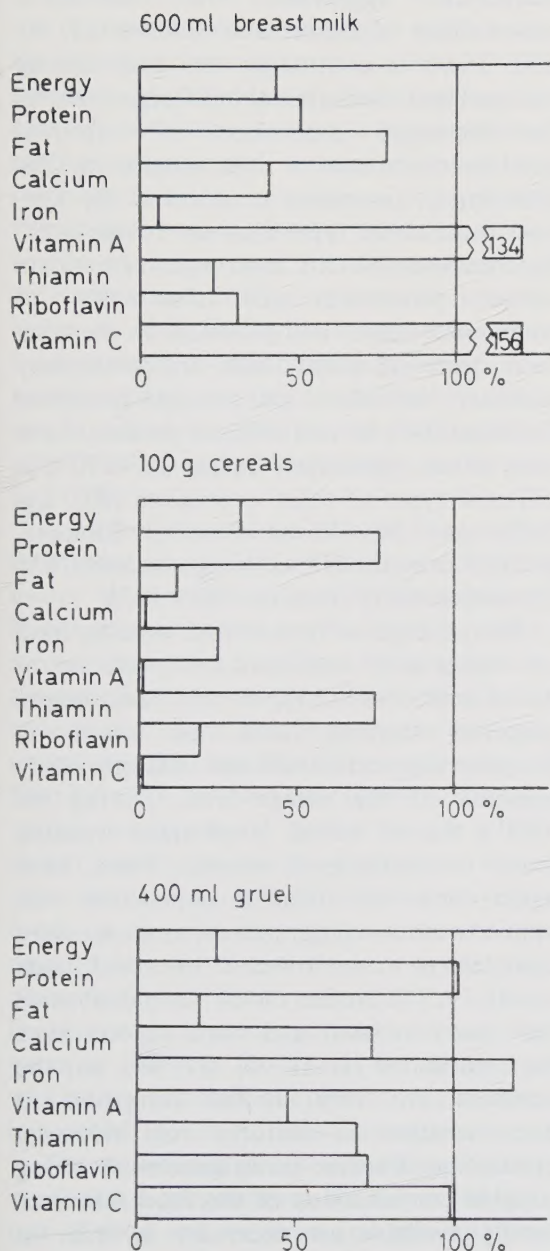
The recommended intakes of energy and nutrients per kg body weight for infants and children are high compared with those for adults (84). However, evaluation of the nutrient density, i.e. quantities of these recommended nutrients per energy unit, shows that this density does not differ markedly from the nutrient density recommended for moderately active adult women (84). There are, however, two factors which need to be taken into account when comparing the requirements of infants and younger preschool children with adults. First, the average energy needs of young children are estimated at 100 Kcal (420 KJ) per kg body weight, which is more than twice the figure for the reference woman and man, 40 and 46 Kcal (167 and 192 KJ) per kg body weight, respectively (84). Secondly, there is a great difference in the FAO/WHO estimate of the essential amino acid requirement between the child and the adult when related to body weight, as well as to the amount of nitrogen required (31).

Well-nourished adults have energy and nutrient stores which can be drawn upon to cover the maintenance need for several weeks (8, 83). However, for growing infants and young children, the possibility of balancing variations in the energy and nutrient supply is much lower, partly due to the high energy and nutrient requirement for growth in relation to body size and partly due to the limited metabolic capacity of their liver and kidneys. Considering the fact that the nutrient density required for older infants and young children is the same as for adults, it is true that "children do not need special foods" and the

family diet should be sufficient (28). However, the food habits of adults often make it necessary, both in industrialized and in developing countries, to modify the relative amount of foods used by the family, the meal size and the frequency of meals so as to cover the child's relatively high need of energy and the requirement of high quality protein. Consequently, improved feeding, particularly during the weaning period, is considered by many to be an important measure to combat infant and childhood malnutrition in developing countries (34, 50, 79, 81).

Many surveys show that breast feeding is still common in developing countries, even after the age of 6 months (48) and prolonged breast feeding is of great nutritional importance (22, 46). However, even if an average volume of 600 ml of breast milk is consumed, the breast milk alone covers only part of the recommended nutritional intake for a child of 12 months (Fig. 1 a). The necessity of supplementing breast-fed infants at that age with appropriate, locally available foods is evident. More pressing is the situation of the child who is not breast fed and who, due to poverty and ignorance of the parents, is given mainly unsupplemented cereals as weaning food. The nutritional inadequacy of such feeding is illustrated in Figure 1 b. The increasing nutritional requirements and functional peculiarities of children at this age make it mandatory that they adjust to the family diet gradually and that appropriate transitional diets are instituted at the right time.

After the age of 6 months few babies are breast fed in Sweden (103). The majority of infants after 4 months of age are given industrially produced milk-cereal based gruels in amounts ranging between 200 and 250 ml twice daily. Particularly in view of the fre-



quent use of these gruels and the amounts consumed, their nutritional quality is of great importance. Figure 1 c shows that the nutrient density of the gruel is high, owing to its content of a large portion of cow's milk and fortification with vitamins and minerals. These milk-cereal based products are pre-cooked, usually involving roller-drying, in order to make them ready for use after mixing with water. Furthermore, they are generally sweetened by the addition of sucrose (7). However, during the last few years sucrose has been replaced by other types of sweetening agents, sometimes reducing sugars (36, 97). The processing method may under such circumstances, influence the protein quality to a large extent (58, 62). Often this effect cannot be detected by conventional chemical analyses (13, 16, 62).

In Sweden, foods for the weanling child, in addition to gruel and porridges, are easily available and have a high nutrient density because of the abundance of cow's milk and other milk products, potatoes, enriched bread and table fat (6). Other animal products, besides cow's milk, are also easily available and fruit and vegetables, fresh or deep-frozen, can be obtained all the year round. Furthermore, many children, especially older infants, are given industrially produced baby foods in jars (57), which, on the average, have a high nutrient density (36, 97). However, although the prerequisites for getting an adequate diet are excellent, serious infections are rare, and

Fig. 1. Nutrient content of certain amounts of breast-milk, cereals and milk-cereal based gruel expressed in percent of recommended daily intake for 12 months old infants (84)

a. 600 ml breast-milk; b. 100 g cereals (maize flour, 85 % extraction rate); c. 400 ml gruel.

the health of the children is good, there is still room for improvement in the feeding habits among this age group in Sweden, as well as in other industrialized countries (51, 92, 98).

In developing countries, the food situation and food habits are quite different from those in industrialized countries (11, 37). The general food pattern is characterized by the great importance of staple foods, i.e. cereals and/or starchy roots. Compared with industrialized countries, foods that are needed to supplement the staple foods nutritionally are limited (37). Furthermore, an uneven distribution of available foods among different socio-economic groups, as well as within the family, is a further aggravating factor which needs to be recognised particularly in the evaluation of a child's diet (15, 27, 53). Different approaches have been used to improve the feeding of infants and young children in order to combat malnutrition in developing countries. Interest in processed foods for children arose in the 1950's, initiated primarily by studies showing inadequate protein intakes in low income groups (85). Particularly during the 1960's different types of low-cost protein-rich mixtures were developed and produced in several countries as part of public health programmes and with the aim of combating childhood malnutrition (70, 73, 75, 78, 94). The documentation on this subject is substantial. Thus, two volumes published by the UN organization Protein Calorie-Advisory Group (PAG) are devoted mainly to low-cost protein-rich foods (78). These mixtures were tested in different ways and a guideline for their composition and quality was given by PAG (77). However, such processed food, although cheap, normally reaches only a limited number of the children and not always those who are in greatest need

of improved weaning foods (30, 75, 76).

Disasters of different kinds occur frequently in some areas of the world. Such emergency situations aggravate the nutritional vulnerability of infants and children (17, 40, 83). There is a strongly felt need among national and international relief organizations for increased production of improved products to be used in relief programmes. In this respect pre-mixed products of the low-cost protein-rich type used as "bridge-over" food are valuable until local organizations can initiate production and distribution of traditionally used food products. In the relief work such pre-mixed foods are particularly necessary for infants and younger preschool children (104). Several different products have been in use, particularly during the 1970's, in different types of relief operations (40), e.g. Faffa and Soy-Wheat flour in Ethiopia, DISCO from the United Kingdom and CSM (Corn-Soy-Milk) from the USA (93).

The concepts of home-made weaning food or village-level multi-mixtures were introduced in the 1960's (48, 49, 50). These home-prepared weaning foods are based on products frequently used and relatively easily available at the village level. During the 1970's the so called home-made weaning foods or family-level weaning foods have again come into focus in connection with applied nutrition programmes, as a necessary complement to the low-cost processed foods (1, 20, 79, 81). Studies on the nutritional value have been initiated and some reports have been published (1, 41, 44, 87, 96), but the numbers are very limited compared to documentation on mixtures from industrial production. Further investigations involving suitable combinations of the food resources locally available are necessary in order to

allow realistic information and recommendations to be given to the families and health personnel.

Development of information material for use in mass communication and in the training of health personnel in the context of child nutrition programmes is also receiving increasing attention. Accumulating experience both in national and international work has demonstrated the importance of including village-level weaning food in mother and child health work, as well as the necessity of developing and distributing manuals or hand-books on child feeding on a large scale. One such manual on the feeding of infants and young children has been published by PAG and is meant to stimulate the publication of other locally adopted hand-books on this subject (20).

A method of systematizing the food needed in an adequate diet or a weaning meal can be useful in nutrition education programmes. However, attempts to use food group systems for such purposes have been criticised on the grounds that they have not always been suited to local conditions. Furthermore, the concepts underlying the classification or grouping of food have not followed the realities of the population concerned. At present there is a continued search for simple approaches which take into account the importance of staple foods in the diet in a given area and the manner in which the staple can be supplemented with local resources. A classification system which considers the nutrient value of different foods and the manner in which they mutually supplement one another is a useful tool in nutrition education.

The importance of such a system, not only in education programmes, but also in the context of food and nutrition and planning and

agricultural development undertakings, has attracted attention during recent years (11, 65, 102). At the World Food Conference in 1974, in the resolutions adopted by Committee No. V, it was concluded that "highest priorities should be given policies and programmes for increasing food production and improving food utilization in developing countries" and that "all governments should accept the goal that within a decade no child will go to bed hungry..." (109). The high priority of food and nutrition planning in both developing and industrialized countries was further stressed during the general assembly meeting of WHO in 1977 (90).

However, although an increased production of food, which generally means staple food, is urgent, this is not enough to cover the needs of infants and children under conditions prevailing in developing countries. A more holistic view is therefore necessary within the field of food and nutrition planning, food production and nutrition information. Food needed to supplement the staple diet must be taken into serious consideration in nutrition programmes without at the same time over-emphasizing the need for animal products, which has been the case hitherto (34). Many misconceptions still flourish regarding the type of food required for basic human physiological needs (11, 102).

Aims of the present investigation

Nutritional studies on foods for infants and younger preschool children in developing and industrialized countries have been carried out, with the following aims:

1. To evaluate the accuracy and reproducibility of a method for total-N analyses

in different biological specimens, using a block-digestor and automatized ammonia determination;

2. To develop a new food group system as a pedagogic tool in nutrition planning and information;
3. To evaluate the protein quality in different wheat-based blends in order to allow recommendations to be given on the composition of a mixture for use in emergency situations;
4. To formulate home-made weaning foods adapted for a developing country and to study the nutritional value of these mixtures;
5. To evaluate the protein quality of some of the most commonly used Swedish milk and milk-cereal based products and to compare the results to given standards (77);
6. To study the effect of different compositions and drying procedures on the protein quality of sweetened milk-cereal based products; and
7. To enable a comparison to be made of the nutritional value of some recommended meals and daily menus intended for use either in developing or industrialized countries.

Methods

Amino acid analyses were carried out by means of an automatic amino acid analyzer. Further details are given in papers I, III and IV.

Total nitrogen content was determined by the automatized procedure described by Mossberg (72), using a thermostated aluminium block for acid digestion and a Technicon Auto-Analyzer for ammonia deter-

mination, as described in paper I. For calculating the crude protein content, the conversion factor of 6.25 was used.

The chemical composition of foods was determined mainly according to the methods recommended by AOAC (74) (except for crude protein, see above), or otherwise as described in the respective papers.

Calculation of nutrient content and nutritional quality

Total energy and nutrient contents were calculated by conventional methods, using the food composition tables referred to in the respective papers (II, IV and VII).

Chemical score was calculated by the method described by FAO/WHO (54), using as reference the egg protein pattern in paper III (35) and the FAO/WHO 1973 provisional pattern in papers IV, VI and VII (54). In paper IV and VII adjusted chemical scores were calculated as recommended by FAO/WHO 1976 (31).

Amino acid data for products not analysed chemically were taken from the FAO tables of amino acid contents of foods (5):

Protein-energy ratios were calculated as follows:

$$P_E \% \times \frac{\text{crude protein (g)} \times 4 \text{ (Kcal/g)}}{\text{energy (Kcal)}}$$

a NDpE % = chemical score x NPU (Net protein utilization)

or

$$\text{b NDpE \%} = \text{chemical score} \times P_E \% \frac{54 - P_E \%}{54 - P_m \%}$$

according to Miller and Payne (69).

P_E % = protein energy %.

NDpE % = net dietary protein energy %.

$$P_m = \frac{400}{\text{chemical score}}$$

The adequacy of the nutritional values estimated was evaluated by means of the standards given by FAO/WHO (84) or as described in the papers.

Nutritional profiles were outlined on the basis of nutrient density calculations as described by Hansen (45) and with further details as given in papers II and VII.

Biological evaluations of protein quality were made on a 10 % protein level in the test diets.

Protein-efficiency ratio (PER) was estimated mainly according to the method of Campbell (21), with the modifications given in paper III.

Net protein utilization (NPU) was determined directly, using the method described by Miller and Bender (68), modified as described in paper V. The NPU values in paper IV were obtained by multiplying BV (Biological value) x TD (true digestibility).

Biological value and *true digestibility* were determined by means of the nitrogen balance test described by Eggum (29) and with the modifications given in papers IV, VI and VII.

Statistical calculations were performed by conventional methods using a desk computer (Compucorp Statistician).

Present investigation

Total nitrogen analysis in nutritional evaluations (I)

In assessment of the nutritional value of individual foods, mixtures and meals, the protein quantity and quality is of central interest. The total protein, i.e. the crude protein content, is usually determined indirectly by

analysis of the total nitrogen content. Knowledge of the total nitrogen content is also necessary when evaluating the protein quality both chemically, by calculation of the chemical score, and by biological assays. Hitherto, the total nitrogen has usually been determined by the conventional Kjeldahl method (55), which is time-consuming. It therefore seemed that simplification and automatization would be of practical and economic value, especially in view of the large numbers of samples that need to be analysed in nutrition research. The most time-consuming part of the procedure has been the acid digestion.

A method was used in the present study which permitted digestion of 40 samples within 2 hours. This was made possible by using a device for block digestion, which also meant improved standardization. Furthermore, the advantage of a rapid automatized method for the determination of ammonia colorimetrically was gained (71).

The results obtained from about 100–200 casein analyses per year during a 4-year period were evaluated statistically. No significant differences ($P < 0.05$) were found between the means of the casein total-N content obtained each year. The accuracy of the method compared with conventional Kjeldahl and amino acid analysis for determination of protein was found to be good (Table 1). The experience of analysis of about 10,000 biological specimens (blood, urine, faeces, foods and protein concentrates) throughout a 4-year period showed that with this method

- the recovery of nitrogen is satisfactory
- the reproducibility is good
- a large number of specimens can be digested and analysed
- the same equipment can be used for

Table 1. *Total Nitrogen and Protein Nitrogen Analysis*

Sample	Total nitrogen (mg/ml)			Protein nitrogen (mg/ml)		
	Conven- tional Kjeldahl	Tecator- Technicon	Tecator- Technicon (6 months later)	Conven- tional Kjeldahl	Tecator- Technicon	Amino acid Analysis
A	1.54	1.57	1.57	1.15	1.20	1.12
B	1.44	1.43	1.43	1.05	1.04	1.02
C	2.05	2.09	2.06	1.58	1.64	1.59
D	1.58	1.62	1.62	1.21	1.27	1.22
E	1.98	2.03	2.01	1.57	1.60	1.52
F	1.62	1.65	1.68	1.23	1.30	1.28

simultaneous analyses of various types of specimens

A food group system for use in developing countries (II)

In developing countries the diet is largely based on staple foods, i.e. cereals or starchy roots, starchy fruits or tubers. The composition of the diet is of particular importance in the weaning period, during which physical growth is still rapid and the energy and nutrient requirements are relatively high. To fulfill the nutritional needs during this period the staple foods alone are not adequate, and must be supplemented with sufficient amounts of other types of foods. In nutrition education foods have been classified according to different principles in order to stress the importance of using different food items in a diet.

Food group systems used as pedagogic tools in nutrition education have, however, seldom been adequately adapted to food habits and food availability in Third World countries (4). In many instances the concepts are confusing, for example foods grouped as energy-giving foods, i.e. staple foods, are also the most important protein sources from the quantitative point of view. The system ignores the role of valuable sources of energy in the diet, e.g. fats and sugars, as these products are often grouped together with the staple foods.

A food group system for use particularly in developing countries was elaborated in this study with the intention of stressing the need for supplementary food in combination with the staple food in the diet. The proposed food groups and the reasons for the suggested grouping of the foods are as follows:

Group A.

The diet must be based on the *staple food*, the most easily available and cheapest product which is eaten in the largest amount compared with other products, e.g. cereals or starchy roots, tubers, fruits.

Group C.

The double mixture (A+B) needs to be combined with *vitamin* and *mineral supplements*, i.e. vegetables or fruits, in order to increase the content of vitamins A and C, in particular.

Group B.

The staple needs to be combined with *protein supplements*, e.g. grain legumes, oilseeds or animal products, in order to achieve a sufficiently high protein quality.

Group D.

The triple mixture (A+B+C) may often require *energy supplements*, i.e. fats or sugar in order to increase the energy density.

The practical implication of the suggested food group system was exemplified in this study by a model on how to plan an adequate meal for a weaning child in a developing country. The instruction is meant to be used as teaching material for health personnel.

Studies on foods for infants and children

Protein quality of emergency food mixtures based on wheat (III)

In times of disaster, cereals are usually distributed and constitute the predominant part of the diet. Infants and young children, pregnant and lactating women and the sick need relatively greater amounts of foods which supplement the nutritional inadequacies in cereal-based diets. Foods of the low-cost protein-rich type, or supplementary food, have been used for this purpose in different relief programmes (40). In the early 1970's, it was decided to develop and produce a supplementary food to be based on food items available in Sweden and accessible to different relief organizations (2, 3, 17, 95). Products

suitable for this type of mixture were evaluated and different recipes, all based on wheat, which is a surplus product in Sweden, were formulated. The protein supplements tested were protein concentrates of fish, soy, rapeseed, and whey, dried skimmilk, dried butter-milk, defatted soy flour and field peas in different combinations. Defatted soy flour, although not a Swedish product, was included for comparison in one mixture, as soy was the most commonly used protein supplement in already existing mixtures, e.g. CSM (93). The nutrient composition of all the mixtures followed the PAG guidelines on protein-rich weaning foods (77).

The protein evaluation showed that all the mixtures contained protein of high quality. The chemical score, with the egg amino acid pattern as reference (35), varied between 67 and 79 in the mixtures. When the amino acid pattern suggested by FAO/WHO 1973 (54) was used as reference the score varied between 52 and 111. The determined PER varied between 2.78 and 3.87, as compared with 2.6 for standard casein. There was a

highly significant correlation ($p < 0.001$; $r = 0.94$) between the chemical scores derived with the egg pattern and PER. The best protein quality (PER 3.87 and score 79) was found in a wheat-whey protein concentrate/fish protein concentrate mixture.

Home-prepared weaning foods for use in a poor rural area of South America (IV)

The Altiplano area situated between Bolivia and Peru is characterized by a combination of environmental and economic poverty. The inhabitants belong mainly to the Quechua or Aymara ethnic groups. The area is mostly rural with a subsistence level of agriculture production. The environmental sanitation is poor, water supplies are scarce, illiteracy is widely spread and health facilities are mostly inadequate (33, 64, 91, 101). The mortality rates in infants and young children are high and malnutrition is often a contributory cause of death (86).

So far no published reports on weaning foods in this specific area seem to be available. In order to make use of easily accessible products, nine different meals for weaning children were formulated. To achieve a high-protein quality in these mixtures the staple foods were combined with one of the two types of protein supplements available as shown in Table 2.

Potato in combination with carrots, 25 g of each in the recipes were used as vitamin and mineral supplements.

The NPU of the mixtures varied between 52 and 76. When the chemical score was used for the calculation, the NDpE % improved in all mixtures (7.5–10.6) compared to the separate products (5.1–12.5), with the exception of that in quinoa (*Chenopodium quinoa*), a grain (9.4) and broad beans (12.5). The fat

Table 2. *Proportions (wt:wt) of staples and protein supplements in the weaning mixes.*

		Staple				
		Maize	Barley	Wheat	Potato	Quinoa
Protein supplement	Broad bean	4:1	3:1	3:1	—	2:1
	Quinoa	1:1	1:1	1:1	3:1	1:1

content was low. With an increased proportion of fat the NDpE % decreased to about 5 in two mixtures. It is seen in Figure 2 that the average nutrient content of two portions of the suggested weaning foods and 400 ml breast milk covers the recommended daily intake of energy and nutrients except for calcium.

Protein quality of instant blends (V and VI)

Industrially processed baby foods are used extensively during infancy and early childhood in Sweden. For many infants, and also among younger preschool children, processed foods cover the whole or main part of the daily food intake. In view of this fact and of the nutri-



Fig. 2. Nutrient contents of 400 ml breast-milk and 2 portions of weaning multimix (IV) expressed in percent of recommended daily intake (84).

tional vulnerability of infants, high demands must be placed on the nutritional quality of foods intended for infants and children. Different types of standards for the nutritional quality have been suggested or worked out during the last few years (23, 32). These standards refer also to protein quality measured by means of biological methods. In the first part of this work the most commonly used milk or milk-cereal based products, human milk substitutes and also gruel- and porridge products marketed in Sweden, were studied and the NPU was determined. The results showed that the NPU of human milk substitutes varied between 75 and 78. The protein in these products was derived from spray-dried cow's milk, which in this study (V) was found to have a NPU of 85, compared to the average value of 81.6 reported by FAO (5). Hence the biological evaluation revealed no negative effect of spray-drying on the protein utilization in human milk substitutes.

Milk-cereal based gruels were also found to contain protein with a high NPU (69 to 77) and within the level expected in these types of products, as the major part of the protein is derived from cow's milk and only a minor part is cereal protein.

The *porridge powders* tested, with compositions very similar to that of the gruels and with cow's milk constituting the main part of the protein, had in some cases NPU values (62 to 69) almost comparable to these of the gruels. However, in some products the NPU

were remarkably low (28 to 43). The second part of the study showed that the NPU of the protein varied according to the different roller-drying procedures used and the type of sugar added. In order to obtain cereal-containing products which are ready to serve after mixing with water, the milk-cereal mixture is pre-cooked and thus roller-dried. In some products glucose or fructose was used as a sweetening agent to give a lower risk of caries than with products sweetened with sucrose (7, 36, 97). The addition of glucose to the milk-cereal mixture before roller-drying caused the greatest decrease in the NPU value, from 80 in the product dried with glucose added after the roller-drying to 15 when glucose was present on the drum and when the drying process was continued until the moisture content was lowered to 1.5 % (VI). Lysine supplementation restored the NPU values substantiating a Maillard type destruction.

The protein quality of the processed product thus depends largely on the procedure used and the sweetening agent.

Weaning foods in developing and industrialized countries (VII)

In order to study some of the nutritional characteristics of the diet recommended for children in developing and industrialized countries, the following different types of meals and daily menus were evaluated and compared.

A. *Staple foods*

in developing countries:

1. Breast-milk
2. Cereals (maize)
3. Instant milk-cereal gruel
4. Basic food (basmat for children) (47)
500 ml cow's milk (0.5 % fat), fortified,
100 g bread (fortified), 20 g cheese (low
fat), 125 g potatoes and 30 g cereal-
products.

in industrialized countries i.e. Sweden:

B. *Daily menus*

in developing countries:

1. Recommended for Altiplano South
America
2. Recommended for Tunisia
3. Recommended by the baby food industry
4. A suggested lacto-vegetarian menu

in industrialized countries i.e. Sweden:

C. *Prepared menus:*

in developing countries:

1. Maize based multimix
2. Maize supplemented with breast-milk
3. According to the National Board of Health
and Welfare
4. According to the Baby food industry.

in industrialized countries i.e. Sweden:

The nutritional values of the diets were assessed either by calculations using data from food tables or from chemical studies.

In order to compare the nutrient content of different-sized portions of various foods the nutritional profiles were calculated, i.e. the nutrient content per energy unit in relation to recommended intakes. Only nutrients of primary interest to calculate were included, namely protein, calcium, riboflavin and thiamine, iron and vitamins A and C. In some cases the nutrient contents per total solids were compared. Furthermore, the protein quality of the mixtures were evaluated with use of the chemical score and in some cases

by means of biological protein evaluations (NPU).

The Swedish "basmat" for children (47) and particularly the industrially produced gruels (36, 97) have a high nutrient density. These two types of food could each separately fulfill the nutritional requirements for weanling children, taking into consideration the nutrient content both per energy unit and per volume unit of food. In fact, according to the PAG-definition, these combinations of food can be referred to as "protein-rich" foods for supplementary use (77, 80).

The comparison of the nutrient density of the meals recommended for developing coun-

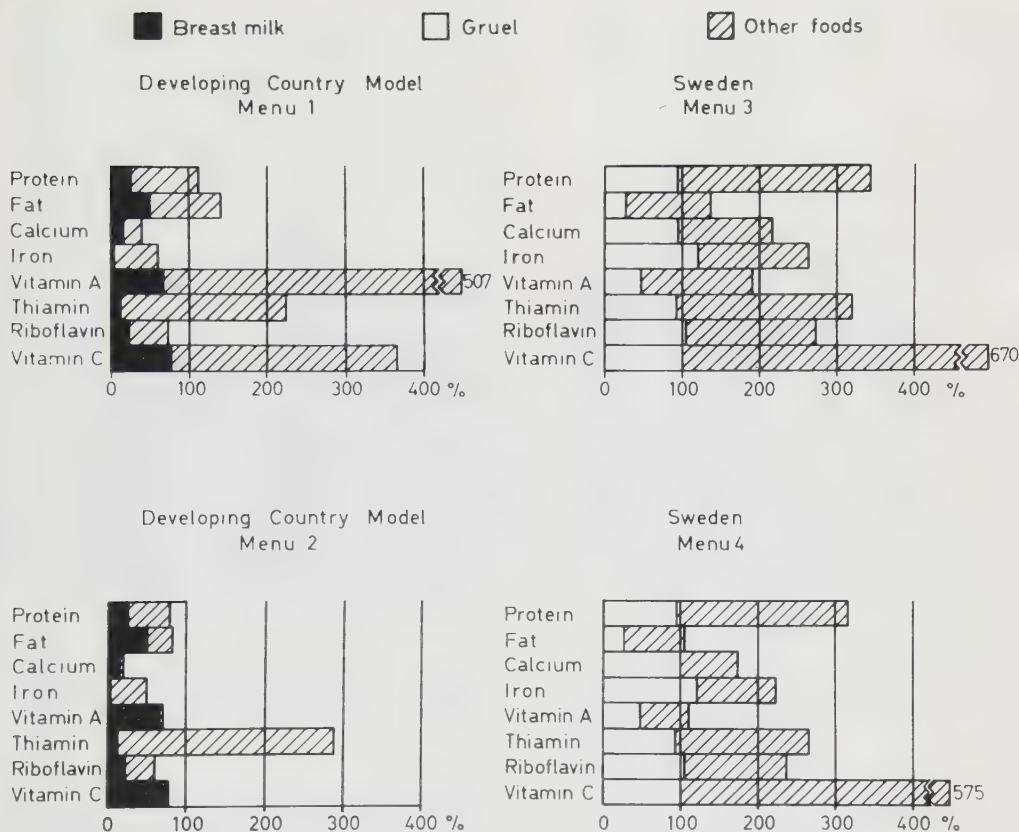


Fig. 3. Nutritional profiles of the four daily menus C₁–C₄ and a lacto-vegetarian menu.

tries showed that this density was adequate when the meals were formulated according to the instructions in paper II. However, the double mixtures with only staple food combined with protein supplements were, even when supplemented with breast milk, nutritionally inadequate. The nutritional profile (45) of the four menus (Figure 3) shows that the protein/energy ratio is considerably higher in examples from Sweden especially when adjusted chemical score is used to indicate differences in protein quality. Compared to

given standards (35), the protein content and quality in these well-balanced meals based on vegetables are sufficiently high. The variations of the content of essential amino acids in the different daily menus are shown in Figure 4. The examples of menus intended for developing countries (B1 and B2) had the lowest concentration of amino acids. Lysine was the limiting amino acid in diet C2 with a score of 57, and in D2, with a score of 68, whilst the sulphur-containing amino acids were limiting in the Swedish menus C3 and C4 with

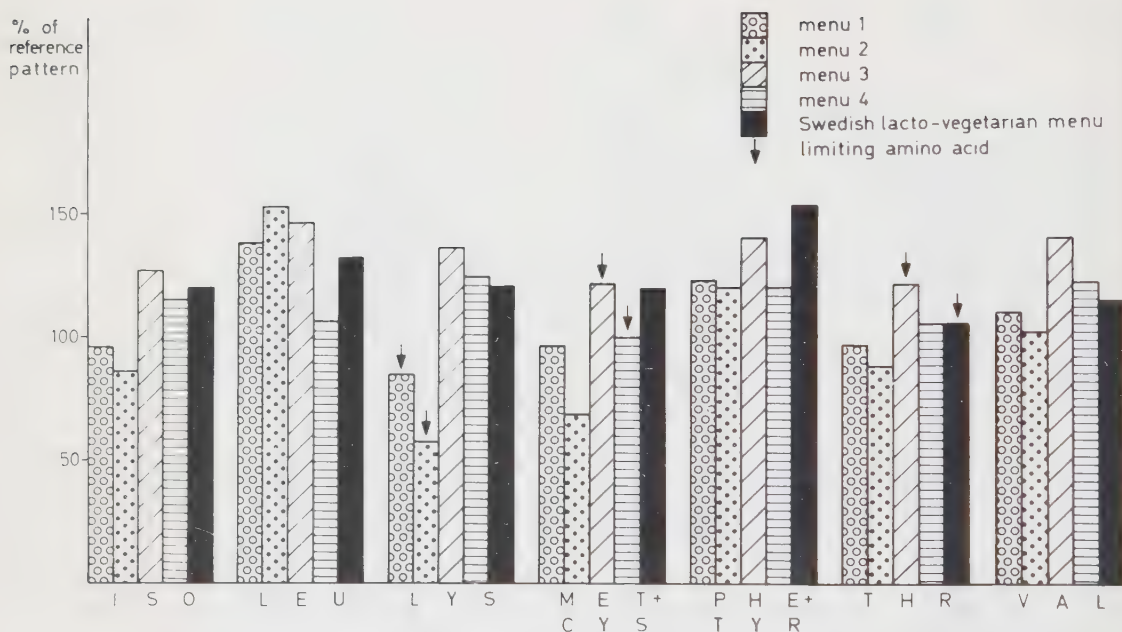


Fig. 4. Content of essential amino acids of the four daily menus C₁–C₄ and a lacto-vegetarian diet expressed

in percent of the FAO/WHO amino acid reference pattern.

chemical scores of 98 and 120, respectively. The score was 102 in the lacto-vegetarian example. The NPU of the four menus B 1–4 were 71, 72, 63 and 60, respectively.

Comments

In this study some commonly held views regarding the differences between the nutritional qualities of foods for infants and children in industrialized and Third World countries were elucidated by means of biochemical analyses, bio-assays and calculated data.

The following observations were made:

- The differences between the staple foods of infants and children in Sweden and in

developing countries are of great nutritional importance. The staple food items for children in Sweden (i.e. instant gruels and porridges, “basic foods” for children) fulfill the energy and nutrient requirement without any supplementation. These foods are also consumed regularly in important quantities and thus the risk for nutrient deficiencies is very small.

- For the majority of children in developing countries breast-milk or cereals, can be considered the staple foods. However, both of these need to be supplemented to cover the energy and nutrient requirements of the weanling child. As the supplements are not always given in sufficient amounts due to

low availability or due to inadequate food habits there is a serious risk of nutritional deficiencies.

- The protein quality, determined as NPU of different meals, varied considerably when industrially produced and home prepared baby foods for use in Sweden as well as in developing countries were studied. The variation of the protein quality of weaning meals adapted to local conditions in developing countries is usually due to different compositions of the meals, and hence differences in chemical score. In Swedish food mixtures, the chemical score is usually high and variations in the availability may be due to inappropriate processing methods. The effect of processing on the protein quality, particularly in foods for infants and children, is recommended to be evaluated during research and development activities of the food industries.
- Recommended daily menus for older infants and younger preschool children in Sweden contain so much protein that they fulfill the definition by PAG for protein-rich foods for supplementary feeding. The recommendation of an increased consumption of cereals and potatoes is also valid for older infants and younger children.
- The nutrient density of well balanced weaning foods containing only foods of vegetable origin and with a low content of fat (10–20 energy %) was adequate in most of the mixtures formulated in this study, with the exception of calcium and riboflavin. When the energy density in such foods were increased by addition of separated fat or

sugar the nutrient density decreased, sometimes to below the recommended levels.

- Information on suitable weaning foods is of essential importance in health and nutrition programmes. In this connection educational tools seem to be a valuable aid for many health workers. Teaching materials, based on the principles for classification of foods suggested in this study need to be evaluated and tested for production and distribution on a large scale in different countries and for different education purposes.
- Experiences from evaluation of nutritional qualities of weaning foods particularly adapted for conditions in Third World countries is that in addition to conventional recommended daily allowances, recommendations based on feeding studies and growth and development studies are needed. These comprise 1) a suitable combination of common staples and protein supplements in order to obtain an adequate protein quality with respect to the nutritional and health status of the target groups; 2) the amount of vegetables and/or fruits generally needed as vitamin and mineral supplements in foods for weanling children; and 3) the minimal amount of fat recommended in mixtures based on different staple-protein supplement combinations.

The relative amounts of different food items, needed to supplement different staple foods can be indicated in the four food group educational system. Thus both the qualitative and quantitative aspects of suitable combinations of foods can be illustrated in this system.

General summary

1. A rapid automatized and standardized method for total-nitrogen determination (Technicon-Tecator) was shown to have good reproducibility and accuracy. The recovery of nitrogen was adequate.

2. A new suggested food group system was based on the facts that

- staple foods, i.e. cereals and starchy roots, are of special importance in developing countries;
- staple foods need to be supplemented with other food to increase the protein quality and the vitamin and mineral contents;
- the energy density of the diet needs special consideration, particularly when weaning foods are concerned;

thus the groups of food needed in combination with staples are

- 1) protein supplements;
- 2) vitamin and energy supplements; and
- 3) energy supplements.

3. A comparison of the nutritional quality of foods for infants and children in industrialized and developing countries showed that

- the protein quantity and quality of well-balanced weaning foods based on vegetable or mainly vegetable sources is, according to biochemical data and bioassays on rats, adequate for weanling children as compared to given standards;
- the protein quality of a Swedish emergency food mixture with a minimal supplementation of animal products is high;
- heat processing of sweetened milk-cereal

based products decreased the NPU values considerably in some cases, and particularly if reducing sugars were present during the heating;

- as both the protein concentration and the protein quality are high in Swedish conventional foods for infants and children they by themselves fulfill the recommendations for protein-rich supplementary foods given by PAG;
- an increase of the fat content of vegetable-based weaning mixtures gives a decrease in the NDpE %; and
- the nutrient density of Swedish basic diet ("basmat") for infants and children and of milk-cereal based gruels was shown to be so high that these foods could fulfill the nutritional requirements without supplementation, whereas in developing countries the basic foods are not adequate, as in the case of breast milk where the volume is insufficient and in the case of unsupplemented staples where the quality is inadequate and supplementation with other types of food becomes necessary.

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